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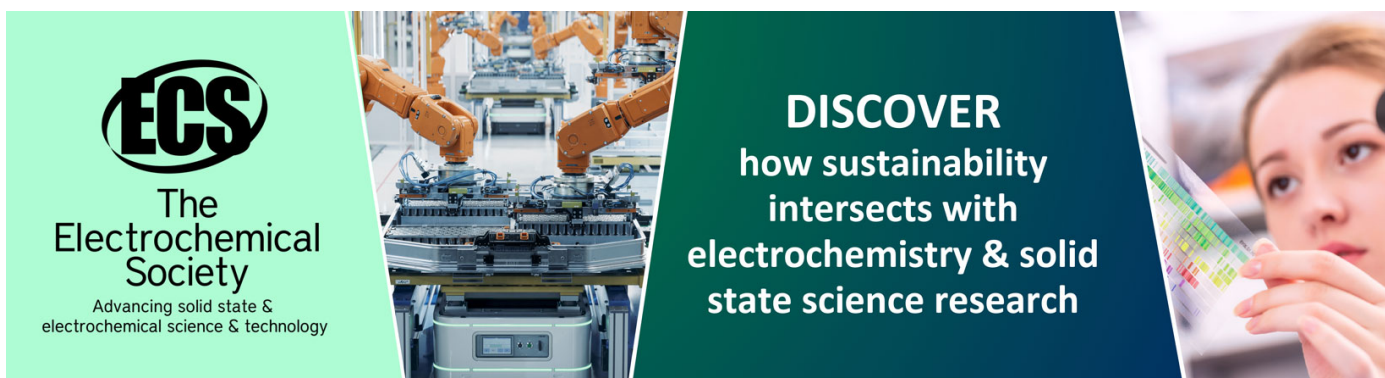
Analysis of Seismic Performance of Reinforced Concrete Framed Structure

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Retraction

Retraction: Analysis of Seismic Performance of Reinforced Concrete Framed Structure (*IOP Conf. Ser.: Mater. Sci. Eng.* **1145 012077)**

Published 23 February 2022

This article (and all articles in the proceedings volume relating to the same conference) has been retracted by IOP Publishing following an extensive investigation in line with the COPE guidelines. This investigation has uncovered evidence of systematic manipulation of the publication process and considerable citation manipulation.

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[1] Cabanac G, Labbé C and Magazinov A 2021 arXiv:[2107.06751v1](#)

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Analysis of Seismic Performance of Reinforced Concrete Framed Structure

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Abstract. This paper deals with the study of behavior of RC frames design for gravity (GF) and earthquake load (EQF). Nonlinear push over analysis was done using SAP on the models (GF & EQF). The functioning of RC frame is estimated in terms of displacement, shear, and performance point and inters story drift. The results from push over analysis for GF and EQF are compared with each other. An approach of the performance level of a 2D frame (PBF) has been done by using the Deformation based earthquake design with the displacement required to be achieved for the performance level as specified in FEMA 356. Here the yield strength is calculated for the required target displacement and the PBF frame is redesign by strength based. Hinges are developed in the ground floor vertical member while carried out the seismic design and only in beams in EQF this represent the strong beam column weak beam concept is applied and inter-story drift is more in top floor for GF and almost similar in all the floors for EQF. Yield shear strength obtained is almost equal to that of the analysis for Performance based frame.

Keywords: Design Basis Earthquake, Multi Degree of Freedom, Peak Ground Acceleration, Peak Spectral acceleration, Coefficient of Drift, Performance based frame, Nonlinear Static Procedure, Spectral Acceleration, Plastic hinge formation.

1. Introduction

In India most of the Reinforced Cement Concrete (RCC) buildings are considered for gravity loads with inadequate lateral load resistance. Buildings are designed for lateral forces to provide adequate strength [1-3]. To achieve the strength requirement, we have to focus on member design and reinforcement. The main goal during extreme earthquake is to save the protection of building as per earthquake design requirements of building codes. Collapse for structure should be at an acceptable low level.

Performance-based seismic design involves a set of process under earthquake loading by which a structure is designed for performance levels in a organized manner. As herein, the process when conducted in professional practice is often based on pushover analysis, a nonlinear static procedure that accounts for both geometric and material nonlinearity at multiple performance (loading) levels.

To find the accurate estimation of seismic demand parameters performance-based design methodologies is very important [4-8]. To find out the earthquake in structures, nonlinear static procedures are widely used. The present study shows different NSPs with different software packages



are used to find the damage parameters and performance evaluation of RC multi-story buildings & Displacement based seismic design procedure is also used in the investigation for achieving performance level for the required target displacement.

1.1. Objectives

The aim of the paper is to identify the functioning of Reinforced structure in multi-story building using Pushover analysis procedure.

The objectives of the study are:-

1. Push over Analysis is to carry out for frames designed for earth quake and only gravity loads.
2. Comparison of the parameters from pushover analysis for GF and EQF.
3. To design a 2D RC frame building using Displacement based approach.

2. Methodology

2.1. Pushover Analysis

Pushover Analysis is analysis for performing dynamic seismic loading and Figure 1 shows the static approximation used in push over analysis.

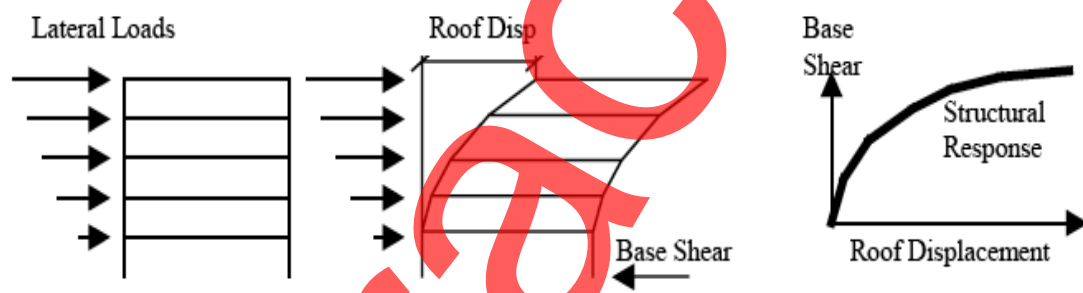


Figure 1. Static Approximation Used in the Pushover Analysis

After ground shaking, functioning of the structure is identified by the client, architect and design engineer. The functioning level of the Building depends on the structural element and non - structural elements of the structure [9-10]. Some common Building function Levels are shown in Figure 2.

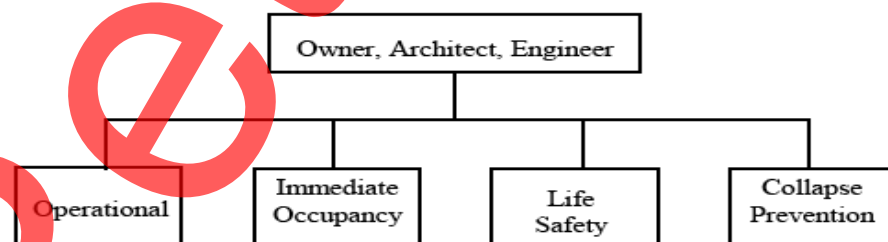


Figure 2. Common building performance

Based on Building function level of the building, the Response Spectrum for the design earthquake may be determined [11-12]. The Response Spectrum gives the maximum acceleration, or Spectral Response Acceleration, a structure is likely to experience under the design ground shaking given the structure's fundamental time period and vibration. This relation is shown qualitatively in Figure 3 and displacement is shown in Figure 4.

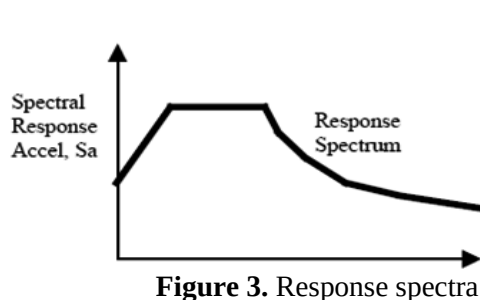


Figure 3. Response spectra

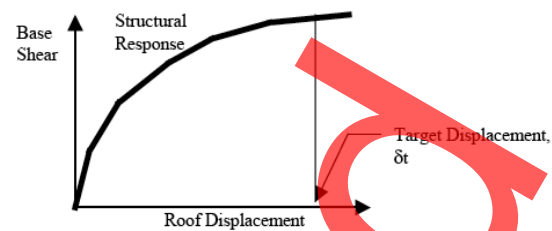


Figure 4. Capacity Curve

2.2 Modelling of Members

2.2.1 Modelling of Slabs, Beams and Columns

For regular structures, slabs are not drawn for analysis. Applied Self weight, dead load and live load is moved to the nearby beams. The bending members and vertical members are drawn as frame elements.

2.2.2 Seismic Risk Levels

In the push over analysis, seismic risk level is related to ground motion. The seismic level as per FEMA356 as shown in Table 1 the hazard level assumed in this project is design based earth quake.

Table 1. Earth Levels (FEMA 356)

Earthquake levels	P	t (years)	N (years)	Approximate N (years)	Remarks
Serviceability earthquake – 1	50%	50	72	75	Frequent
Serviceability earthquake – 2	20%	50	224	225	Occasional
Design basis earthquake	10%	50	475	500	Rare
Maximum considered earthquake – 1	5%	50	975	1000	Very rare
	10%	100	949		
Maximum considered earthquake – 2	2%	50	2475	2500	Extremely rare
	10%	250	2373		

2.2.3 Details of the frame consider for push over analysis

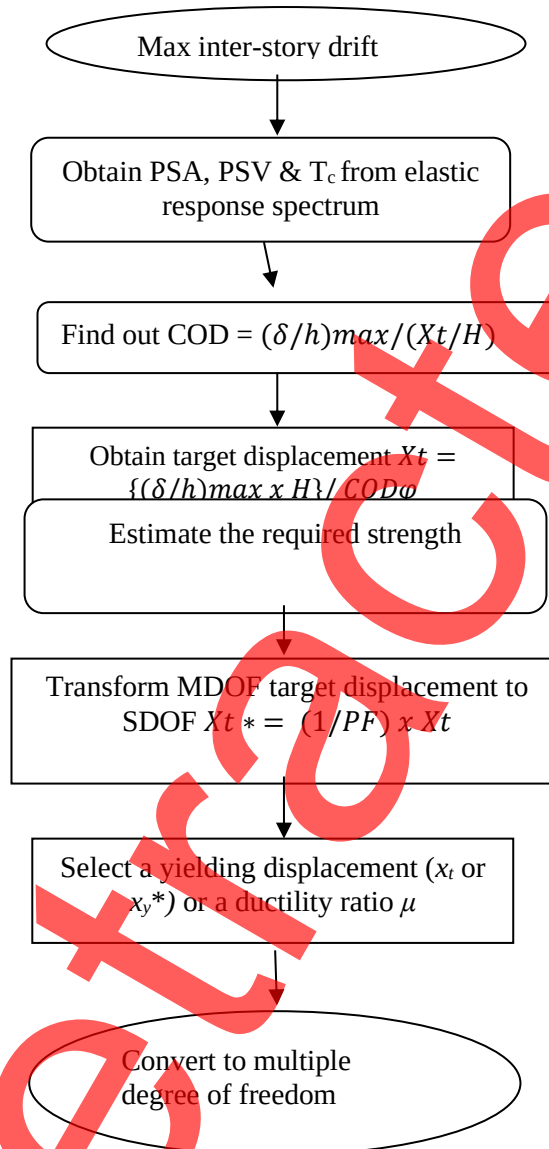
The 4 - story building is situated in seismic zone 4 for carrying out seismic analysis and the building was designed by using seismic codes. The plan is irregular in nature.

2.2.3.1 Analysis and Design of 4-Storey Building

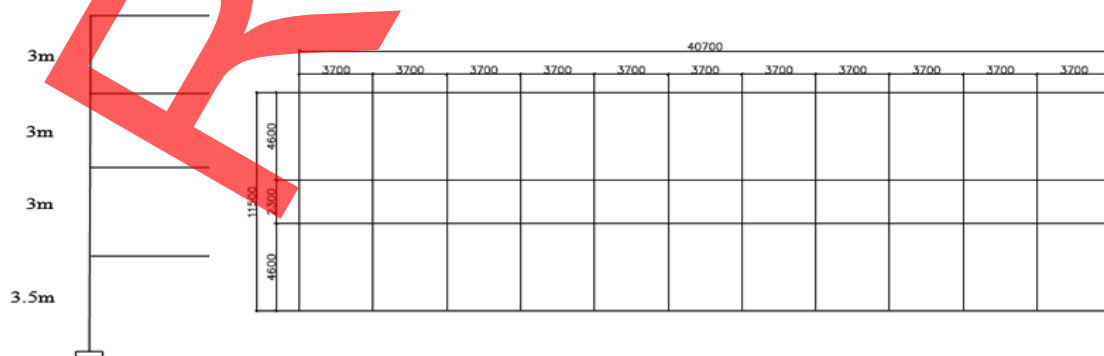
Analysis was done for 4-storey building in ETABS software, forces and moments were calculated. Analysis results were taken from the modelling of 4-story structure. As per code design and detailing was done for 4-storey structure. Design and detailing was done for structural elements like beams and column for maximum moment and shear.

2.3 Displacement Based Seismic Design

2.3.1 Displacement Based seismic Design procedure



3. Results and Conclusion



Elevation Plan

3.1 Results from Pushover Analysis

3.1.1 Push over Curve for Conventional Design

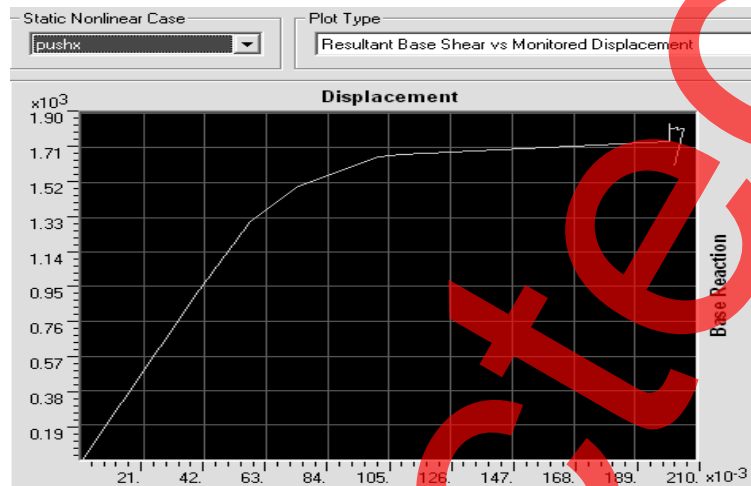


Figure 5. Push over curve for GF in X-direction

Push over curve from the Figure 5 it is seen that GF the base shear attained is 1850kN and the building lateral displacement is 203mm for the collapse for a ground motion in X-direction.

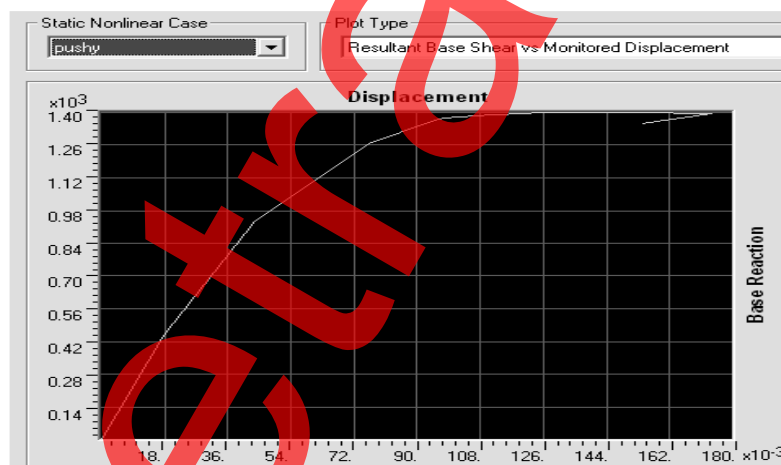


Figure 6. Push over curve for GF in Y-direction

Push over curve from the Figure 6 it is seen that GF the base shear attained is 1400kN and the building lateral displacement is 180mm for the collapse for a ground motion in Y-direction.

3.1.2 Push over Curve for EQ Design



Figure 7. Push over curve for EQF in X-direction

Push over curve from the Figure 7 it is seen that EQF the base shear attained is 3900kN and the building lateral displacement is 216mm for the collapse for a ground motion in X-direction.

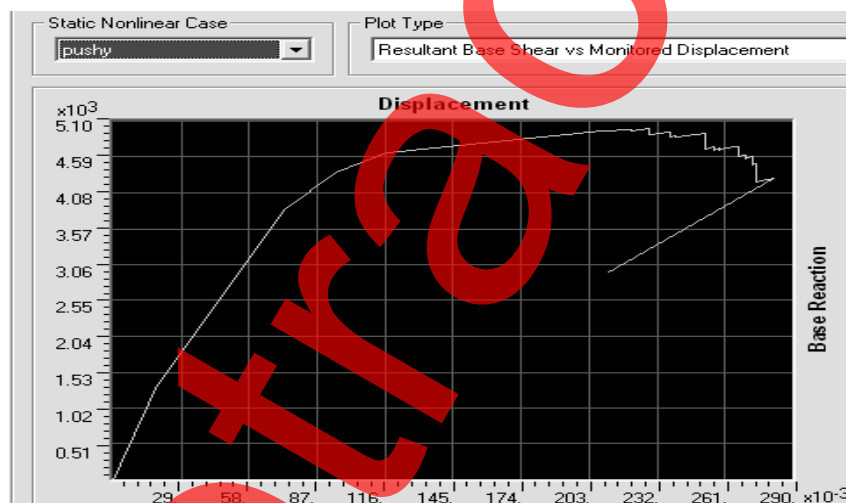


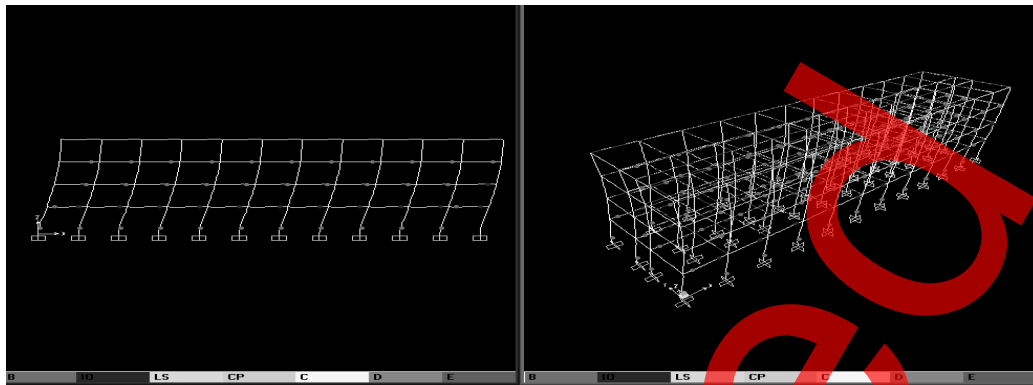
Figure 8. Push over curve for earth quake design in Y-direction

Push over curve from the Figure 8 it is seen that EQF the base shear attained is 5100kN and the building lateral displacement is 285mm for the collapse for a ground motion in Y-direction.

The base shear for the EQF is higher than that of GF in X&Y direction by 51% and 72% respectively. The average lateral displacement of EQF is 23% higher than the GF. The increase in the base shear is due to the design of beams and columns due to the lateral loads which is going to increase the stiffness of the structure.

3.2 Plastic Hinge Formation

3.2.1 Plastic hinge formations for conventional design



In the GF the formation of hinges is taken place in both the beams and columns the state of occupancy is directly to life safety in X-direction.

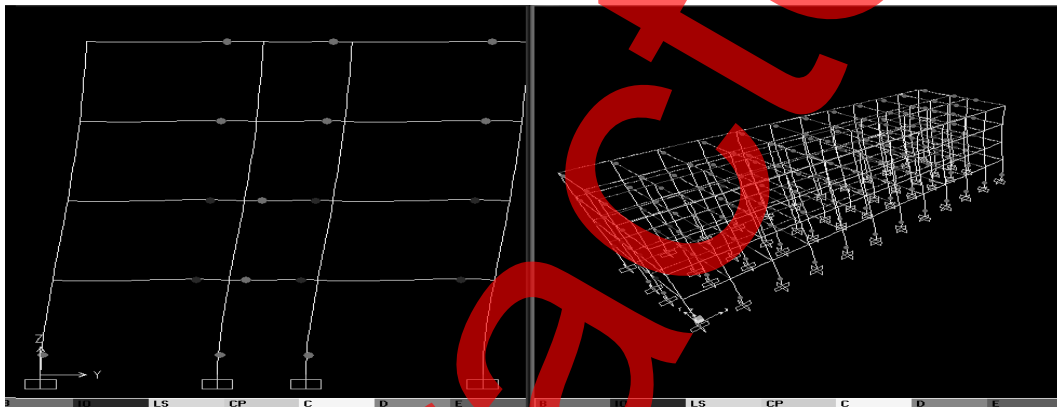
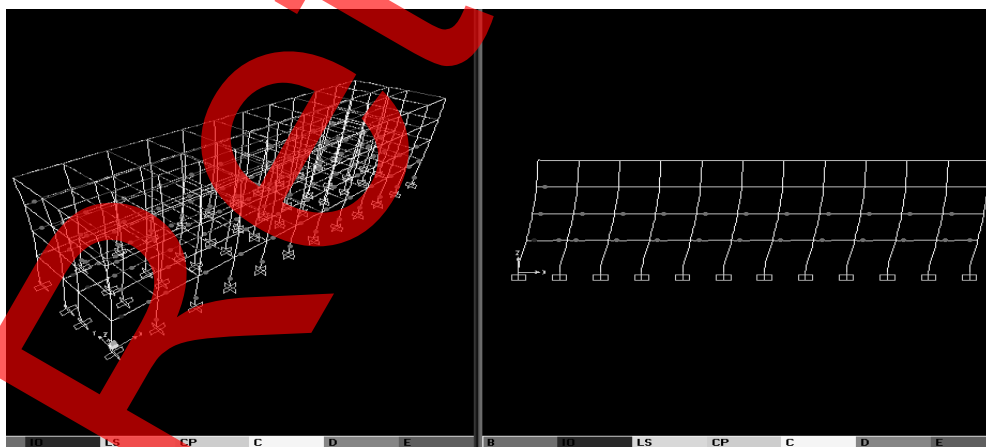


Figure 9. State of hinge formation for GF

In conventional design the formation of hinges is taken place in both the beams and columns the state of occupancy is directly to immediate occupancy in Y-direction as shown in Figure 9.

3.2.2 Plastic hinge formation for EQ design



In the EQF the formation of hinges is taken place in the beams the state of occupancy is directly to immediate occupancy in X-direction.

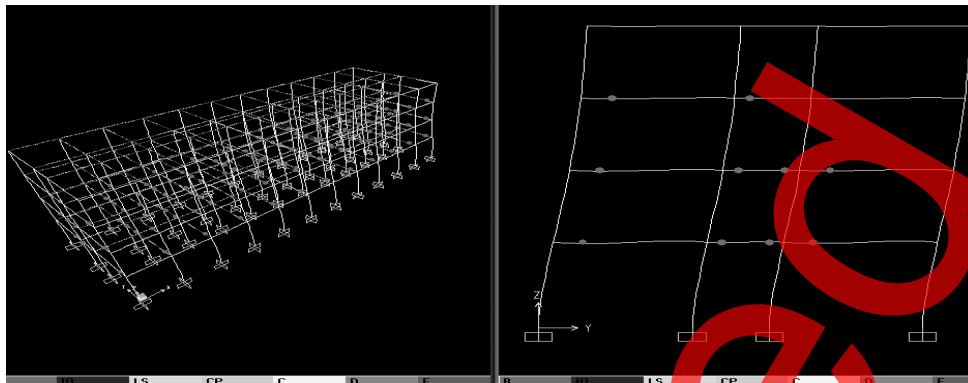


Figure 10. State of hinge formation for EGF

In the EQF the formation of hinges is taken place in the beams the state of occupancy is directly to operational in Y-direction GF both X&Y direction all the ground columns are having plastic hinges and in the EQF only beams are having the plastic hinges as shown in Figure 10.

3.3 Inter-story Drift

Figure 11 and Figure 12 shows inter-story drift for Ground floor in both X&Y direction

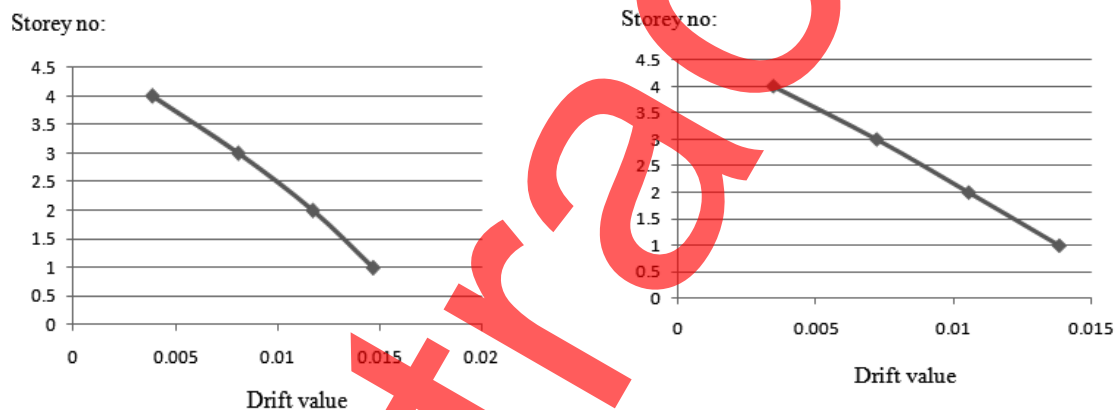


Figure 11. Inter-storey drift for GF in both X&Y direction

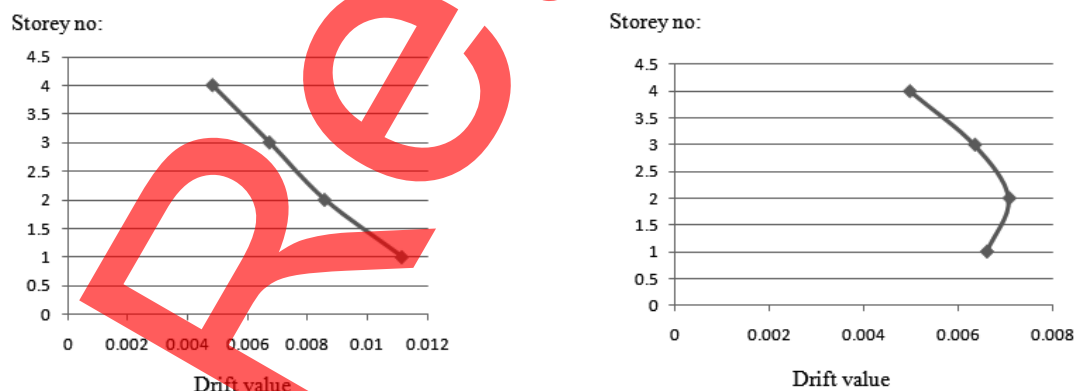


Figure 12. Inter-storey drift for EQF in both X&Y direction

The stiffness is not varying from one story to the other in EQF where as in GF the variation is high. The max value is 0.01468 for GF and the max value is 0.01115 for EQF. The value of EQF is 31% lesser than GF.

3.4 Yield Strength from SAP Analysis

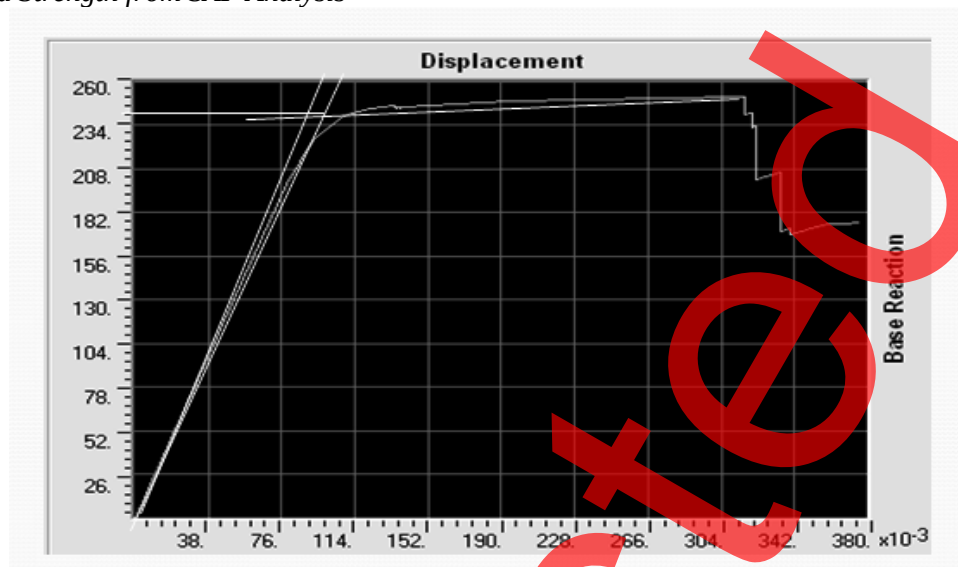


Figure 13. Yield Strength from Push over Analysis

$V_y(a)$ from the SAP analysis is 242.4kN

The $V_y(a)$ shear force in Y-direction result is than in the case study of $V_y(c)$ from displacement based design. The design is in the safer side for the performance objective. Figure 13 shows Yield Strength from Push over Analysis and Figure 14 shows the column labels. Table 2 shows the PBF and re-design of PBF

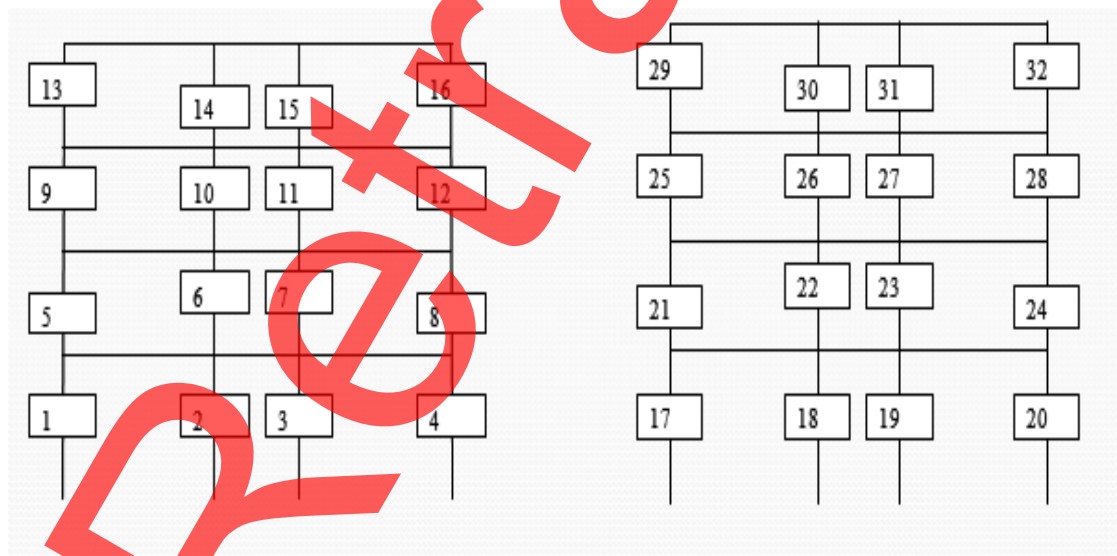


Figure 14. Column Label

Table 2. PBF and re-design of PBF

PBF			Re-design PBF		
Column Label	Size mm x mm	Percentage of reinforcement	Column Label	Cross Section mm x mm	Percentage of reinforcement
1,4	300x500	1.675	1,4	300x500	1.675
2,3	300x500	1.675	2,3	300x500	1.675
5,8	300x450	2.327	5,8	300x450	2.327
6,7	300x450	2.327	6,7	300x450	2.327
9,12	300x400	2.618	9,12	300x450	2.327
10,11	300x400	2.618	10,11	300x450	2.327
13,16	300x350	2.394	13,16	300x400	2.094
14,15	300x350	2.394	14,15	300x400	2.094

4. Conclusion

From the analysis and design the conclusion are as follows:

1. The base shear for the EQF is of 3900kN and that is 2 times greater than the base shear of GF.
2. From the analysis maximum inter storey drift occurs in top storey for GF is of 0.0147 and almost same for all the floors for the EQ design is of 0.0112, almost a reduction of 30%.
3. In GF the plastic hinges are formed in both beams and columns but in EQF the hinges are formed in few beams only as expected.
4. The yield shear strength V_y (a) from the SAP analysis is 6.7% higher than that of V_y (c) in which the design is satisfying the performance level.

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